

Case Report

Indocyanine green fluorescence-guided laparoscopic liver resection for hepatocellular carcinoma: a case report

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ABSTRACT

Indocyanine green (ICG) fluorescence imaging has emerged as a useful adjunct in laparoscopic liver surgery, providing real-time visualization of hepatocellular carcinoma (HCC) and assisting in tumor localization and determination of the parenchymal transection plane. Its role is particularly relevant in achieving adequate oncological clearance while preserving uninvolved liver parenchyma. A 60-year-old man with hepatitis B infection on treatment presented with abdominal pain and loss of appetite. Contrast-enhanced computed tomography demonstrated a solitary 5.1×5.8×5.7 cm segment 3 lesion with arterial-phase enhancement and venous-phase washout, consistent with HCC. Liver function was preserved, with no evidence of portal hypertension. ICG was administered intravenously at a dose of 0.5 mg/kg, 48 hours before surgery. During laparoscopy, near-infrared fluorescence imaging clearly identified the tumor and delineated its boundaries from the surrounding liver parenchyma. The fluorescence was used to guide parenchymal transection, and a laparoscopic left lateral sectionectomy was performed. Histopathological examination demonstrated a 6×5.5×4.8 cm well-differentiated HCC, with a tumor-free resection margin and pathological stage pT1b. ICG fluorescence imaging provides real-time intraoperative guidance during laparoscopic liver resection. In selected patients with HCC, its use may facilitate accurate tumor localization and margin-oriented parenchymal transection while preserving uninvolved liver parenchyma. Further prospective studies are required to establish whether routine use of ICG fluorescence translates into improved long-term oncological outcomes.

Keywords: Indocyanine green, Near-infrared fluorescence imaging, Laparoscopic liver resection, Hepatocellular carcinoma, Fluorescence-guided surgery

INTRODUCTION

Laparoscopic liver resection has become an established treatment for selected patients with hepatocellular carcinoma (HCC).¹ Accurate intraoperative localization of the tumor and identification of an appropriate transection plane are therefore essential, particularly when the lesion is not clearly distinguishable from the surrounding liver on conventional laparoscopic inspection. Indocyanine green (ICG) fluorescence imaging has emerged as an intraoperative navigation technique that provides real-time visualization of hepatic tumors using near-infrared fluorescence.^{2,3} With the increasing application of minimally invasive liver surgery, ICG fluorescence has

gained particular relevance in laparoscopic hepatectomy by facilitating preservation of functional liver parenchyma while maintaining adequate oncological clearance and guiding the appropriate transection line.⁴ Here, we present a case of HCC managed by ICG fluorescence-guided laparoscopic left lateral sectionectomy, highlighting the application of preoperative ICG administration and real-time fluorescence guidance for tumor localization and precise parenchymal transection.

CASE REPORT

A 60-year-old man with no significant comorbidities, a known case of hepatitis B infection on treatment,

presented with abdominal pain and loss of appetite. He had an ECOG performance status of 1. On examination, he had no pallor or jaundice. The abdomen was soft, with a vague, non-tender mass measuring approximately 4×4 cm in the epigastric region. Contrast-enhanced computed tomography (CECT) of the abdomen revealed a well-defined, isodense, arterial-phase enhancing lesion in segment 3 of the left lobe, measuring 5.1×5.8×5.7 cm (AP×TR×CC), with venous-phase washout, reported as HCC (Figures 1 and 2). The liver was normal in size, with a regular surface. FibroScan demonstrated a liver stiffness of 6.5 kPa, and portal venous doppler showed no evidence of portal hypertension. The HBV viral load was 92 IU/ml, and serum alpha-fetoprotein was 47.99 ng/ml. Liver function was preserved, with total bilirubin of 0.4 mg/dl, albumin of 3.9 g/dl, and INR of 0.87. In view of the solitary segment 3 HCC, preserved hepatic function, absence of portal hypertension, and good performance status, the patient was planned for laparoscopic left lateral sectionectomy.

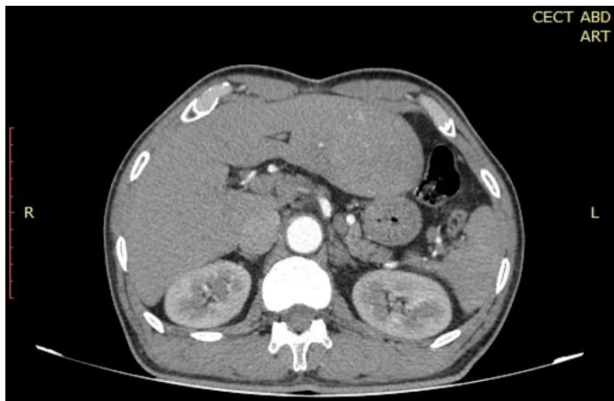


Figure 1: CECT of the abdomen showing a well-defined, arterial-phase enhancing lesion in segment 3 of the liver.



Figure 2: CECT of the abdomen showing venous-phase washout of the segment 3 lesion.

ICG was administered intravenously at a dose of 0.5 mg/kg, 48 hours before surgery. During laparoscopic exploration, near-infrared fluorescence imaging was performed to identify the location of the tumor and

delineate its boundaries from the surrounding liver parenchyma (Figure 3). The fluorescence was used as an intraoperative guide during parenchymal transection. Laparoscopic left lateral sectionectomy was then performed, and the resected specimen was sent for histopathological examination (Figure 4). Histopathological examination demonstrated a well-differentiated HCC measuring 6×5.5×4.8 cm, and the resection margin was free of tumor (pT1b).

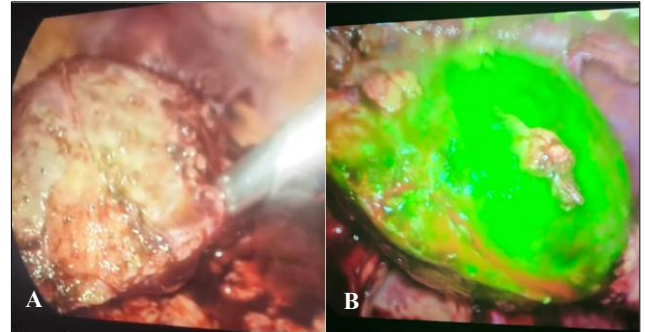


Figure 3 (A and B): Intraoperative visualization of the segment 3 lesion with and without NIR fluorescence imaging, demonstrating ICG fluorescence and clear delineation of the tumor from the surrounding liver parenchyma.

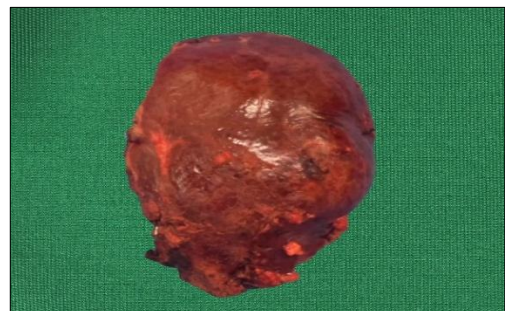


Figure 4: Gross specimen of the resected liver segment demonstrating the lesion.

DISCUSSION

ICG fluorescence imaging has emerged as a useful adjunct in liver surgery, particularly during laparoscopic hepatectomy for HCC. Although direct laparoscopic inspection, palpation, preoperative cross-sectional imaging, and intraoperative ultrasonography remain the mainstays of intraoperative assessment, ICG fluorescence provides an additional real-time visual modality for tumor localization and delineation of the tumor boundary. Following intravenous administration, ICG rapidly binds to plasma proteins and is taken up by hepatocytes. In normal hepatocytes, ICG is subsequently transported into the biliary system, predominantly through canalicular transport mechanisms including multidrug resistance-associated protein 2 (MRP2), resulting in rapid clearance from the hepatic parenchyma.

In HCC, hepatic uptake of ICG may remain preserved, whereas biliary excretion is impaired or delayed because of altered hepatocellular and canalicular function. This imbalance results in preferential retention of ICG within tumor tissue and allows its visualization under near-infrared light.⁵

Ishizawa et al established the feasibility of ICG fluorescence for intraoperative detection of HCC and margin-oriented resection.² ICG fluorescence is particularly valuable for superficial or subcapsular tumors, small or difficult-to-localize lesions, and laparoscopic resections. It can provide additional information regarding tumor localization and extent during surgery and may assist in determining an appropriate parenchymal transection line.⁴

The optimal dose and timing of ICG administration, however, have not been completely standardized. A systematic review by Wakabayashi et al in 2022, which evaluated 72 studies, reported that 0.5 mg/kg was the most commonly used dose for tumor detection, with administration generally occurring within 14 days before surgery.⁶ Other studies have suggested that administration 24-48 hours before surgery may provide favorable tumor-to-background contrast. The authors emphasized that the dose and timing should be individualized according to liver function, tumor characteristics, and the fluorescence imaging system used.⁶

ICG fluorescence offers several potential advantages during laparoscopic liver resection. It can identify tumors that are inconspicuous under conventional white-light inspection, provide real-time visualization of tumor boundaries, assist in selecting the parenchymal transection line, and potentially reduce unnecessary removal of normal liver tissue. Importantly, fluorescence should be considered complementary to, rather than a replacement for, intraoperative ultrasonography because its penetration is limited and deeply situated tumors may not be adequately visualized.⁷ A 2024 systematic review and meta-analysis of 11 studies reported favorable outcomes, with a higher R0 resection rate compared with conventional laparoscopic hepatectomy.⁸

A 2025 systematic review and meta-analysis of 17 studies reported higher R0 resection rates, along with lower operative time, intraoperative blood loss, transfusion rates, and postoperative complications compared with conventional laparoscopic hepatectomy.⁹ Nevertheless, much of the available evidence remains heterogeneous, and long-term oncological superiority has not yet been definitively established.

Routine incorporation of ICG fluorescence into laparoscopic liver surgery, particularly when combined with intraoperative ultrasonography and established anatomical landmarks, may therefore enhance surgical precision and potentially improve perioperative outcomes.

CONCLUSION

ICG fluorescence imaging provides a real-time visual modality during laparoscopic liver resection and can complement preoperative cross-sectional imaging, direct laparoscopic assessment, and intraoperative ultrasonography. In HCC, its ability to demonstrate tumor-associated fluorescence can assist in identifying the tumor, delineating its surface extent, and guiding margin-oriented parenchymal transection.

Although current evidence suggests potential improvements in R0 resection and perioperative outcomes with ICG-guided laparoscopic hepatectomy, ICG fluorescence should be regarded as a complementary navigation tool rather than a substitute for established intraoperative assessment. Further prospective studies are required to determine whether its routine use translates into sustained oncological benefit.

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